Coalition Clean Baltic

FOR PROTECTION OF THE BALTIC SEA ENVIRONMENT

The Swedish Eco-Sanitation Experience

Case studies of successful projects implementing alternative techniques for wastewater treatment in Sweden

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The case studies of eco-sanitation projects have been taken from various articles with the approval and assistance of WRS - Water Revival Systems AB (Ebba af Petersens). Additional information and references are provided at the end of each case study.

Title: The Swedish Eco-Sanitation Experience - Case studies of successful projects implementing alternative techniques for wastewater treatment in Sweden.

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INTRODUCTION

The promotion of good ecological water status through sustainable wastewater management is one of Coalition Clean Baltic's (CCB) priority areas. Promoting examples of the use of ecotechnology measures which aim to provide sustainable eco-sanitation solutions through reducing the nutrient load to the Baltic Sea and the long-term removal of excessive nutrients, particularly phosphorus, from troubled Baltic Sea ecosystems is one way in which CCB is working towards the restoration of the Baltic Sea marine environment.

This report brings together various examples demonstrating the range of alternative techniques for wastewater treatment currently being implemented in Sweden. It is intended to be used by CCB partners and citizens to increase understanding of the methods and technologies available by which further progress towards sustainable wastewater management in the Baltic Sea region (BSR) can be achieved.

Three main techniques are discussed through various case studies of each:

- Urine diversion
- Blackwater systems
- Irrigation using wastewater

URINE DIVERSION

In Sweden urine diversion has been built in ecovillages and demonstrations sites, as well as in summer cottages mainly as a replacement for dry toilets, since the beginning of the 90s. Several rather different examples are described.

CASE STUDY 1 - Tanum

Urine diversion mainstreaming through municipal policy work

Tanum is located on the west coast of Sweden with 12,300 inhabitants. In the summer the number of inhabitants multiplies about five times which results in extreme wastewater flow variations over the year. Furthermore, in Tanum municipality, a large part of the inhabitants live in single houses in the countryside built on rocky terrain which makes connections to the centralized wastewater treatment plant difficult and expensive. Thus, sanitation has high priority on the political agenda. This, together with a political will to strive towards sustainable development, has led to a new municipal sanitation policy that encourages both dry- and dual-flush urine diversion.

Today there are about 400–500 private households (both dry- and dual-flush urine diversion systems), one museum and three camping grounds which have installed urine-diverting toilets. Moreover, conventional dry sanitation in the form of outhouses is common in the municipality due to its character of a summer paradise.

Technical System Design

Toilets	WM-ekologen most common, Gustavsberg
Pipes (indoor)	The municipality recommends Ø110-piping after the water seal
Pipes (outdoor)	Likewise
Tanks	At least 3 m^3 per household is recommended by the municipality. The municipality encourages households to arrange for joint tank solutions for several households.
Emptying/use	Urine is collected once a year by entrepreneurs (on contract) or is emptied by the house owner.
Storage – sanitization	Storage in a separate tank for at least 6 months
Other wastewater fractions	Households with dry sanitation use the faecal fraction in their own garden after composting. Faecal flush water from water flush urine-diverting toilets is treated conventionally.

Organization – local use and cooperation with farmers

To meet the increasing demand for urine-diverting toilets that followed a ban on water toilets in rural settings the municipality started a dialogue with local farmers. Informal recommendations were developed, which in 2002 were turned to a municipal sanitation policy. This policy is one of the most innovative and future-oriented in Sweden today as it requires urine diversion and/or dry sanitation and that this requirement be applied both for rural settings and within the municipal wastewater jurisdiction. There are a number of newly developed areas in Tanum where conventional, tertiary wastewater treatment will be combined with urine diversion.

Roles and responsibilities

The municipality has declared its responsibility for emptying, storage, and use of urine on arable land and it has signed agreements with farmers and contractors who are approved for these activities. The sanitation policy states different ways by which agricultural/horticultural urine use can be achieved:

- For houses located within the municipal wastewater jurisdiction, the urine pipes and tanks are owned by the municipality and the municipality arranges for collection of urine and reuse on arable land.
- House-owners outside the municipal wastewater jurisdiction can either arrange for the emptying and use of urine through a municipally contracted farmer or arrange for a private contractor/farmer to empty their tanks. In the latter case the fee is stipulated separate to the municipal contract. The entrepreneurs/farmers report back to the municipality on their activities once a year.
- House-owners, both within and outside the municipal wastewater jurisdiction, can use urine on their property according to given requirements. However, the municipality must give its approval to each household.

Economy
Households connected to the municipal urine diversion system within the municipal wastewater jurisdiction (where the municipality is in charge of tanks etc) pay the same connection and user fee as households connected to the regular sewer system. Households which have their own urine tanks are charged a reduced connection and user fee. Tanum municipality also works with hardware subsidies for those installing urine-diverting toilets, paying half the investment cost for the households.

Information activities and monitoring
To establish robust urine use contracts the importance of communication between stakeholders has been recognized by the municipality. Farmers using human urine and representatives from the municipality meet twice a year to exchange experiences and to agree on improvements.

In the sanitation policy there are specific requirements for storage and use of urine. There is also general information available both for the householder and the entrepreneurs/farmers.

Lessons learned: Tanum
One of the most interesting things about Tanum is that the municipality has clarified its role and its responsibilities in the sanitation question and defined itself as a central actor in the system. The municipality of Tanum foresees that different options and strategies may be needed to secure the collection and the use of urine in agriculture. This gives the system flexibility over time and also opens up for individual choices for the households. Of course this is based on a strong political support and the assumption that resources are allocated for communication between stakeholders and for good information dissemination.

"Since we used to have cattle, we already had storage tanks and the machines for spreading urine. Our household got an exception from the municipal collection of sewage sludge as we could handle it on the farm, and then the neighbours asked us to collect their urine. In the vicinity there is a summer house area with many urine-diverting toilets, which needed collection. It has ended up to around 100 households from which we collect urine, black water or sludge.

Today, the urine is diluted with sludge from septic tanks and closed tanks. Therefore the nutrient content is rather low and varies a lot. If there were bigger volumes of urine, we could treat the urine separately and would get a much better fertilizer, with a more exact and stable nutrient content."
- Flemming Arvidsson, Farmer, Grebbestad

Figure 1: Tanum, situated in a rocky environment bordering the sea. (source: Tanum municipality)

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- Tanum municipality website: http://www.tanum.se/

CASE STUDY 2 - Elias Fries school in Hylte community

Urine diverting water toilets and biotank for sludge

Elias Fries School has approximately 300 students aged 5–12 years. The toilet system consists of urine diverting water flushed toilets with separation technique for faeces. Separated urine is collected in tanks with a total volume of 20 m^3. Faeces are separated from flush water and then collected in bio chambers. The urine tanks and the bio chambers are placed in the ground and are emptied from the outside. Flush water separated from the faeces fraction and grey water are led to a septic tank and then infiltrated in the ground. The urine tanks are emptied by a farmer twice a year and used as fertiliser. Faeces are composted one year after emptying and then used within the school yard. The amounts of faeces being emptied each year are very small. Pilot scale studies and measurements on a large scale plant has shown that 58-79% N, 50-77% P and 54-90 % K of the content in urine and faeces can be collected with this kind of system.

The system has now been run for 14 years (since 1995) and the porter taking care of the daily running is in the main satisfied with it. As always, when urine diverting systems are installed in public localities, it is important to instruct the users about how to use it properly. It is also very important that the system is installed correctly.

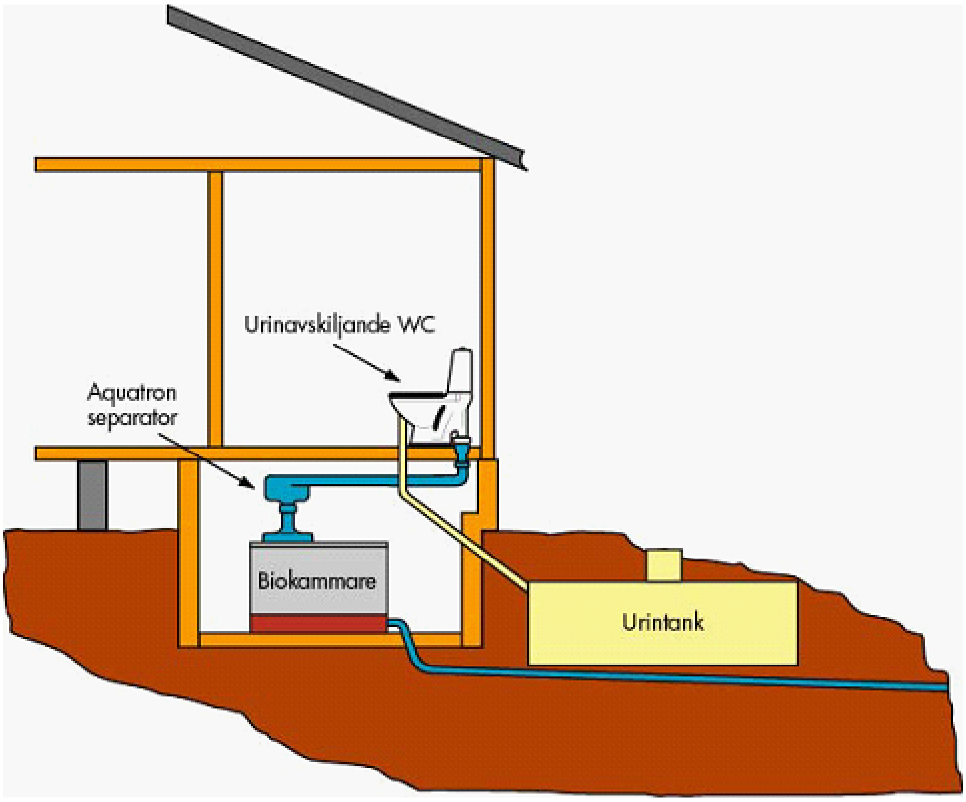

Figure 2: Schematic sketch of a urine diverting toilet with aquatron separator

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- Kenth Backlund, caretaker, +46-(0)345 - 180 31

CASE STUDY 3 - The Understenshöjden project

Local wastewater treatment in an urban area
The Understenshöjden eco-village is situated in the suburb of Björkhagen, a few kilometres south of central Stockholm. The 160 residents are members of a tenant-owner association which includes all 44 apartments.

The estate, which was ready for occupation in 1995, meets high ecological standards with regard to waste management, construction materials, energy systems and the outdoor environment. Urine-separating toilets and a small treatment plant are important components of the local sewerage system.

The toilets are wall-hung Dubbletten models. The urine passes through a copper toilet seal (many of the seals were subsequently replaced by plastic seals) to a system of welded polyethylene pipes with a diameter of 75 or 110 mm. The urine is collected in two series-connected tanks with a capacity of 40 m^3 each. When the first tank is full, the urine mixture overflows into the other one.

About once a year, the urine that has accumulated in the holding tanks is transported to storage tanks at Lake Bornsjön in Salem.The remaining toilet waste and greywater is treated in a local biological treatment plant, after which it undergoes further treatment in a system of ponds and ditches.

Figure 3: the Understenshöjden eco-village (source: Johansson. 2001)

Urine separation and local treatment close to the municipal wastewater system
In Understenshöjden the residents themselves made all the technological choices and decided on system solutions. The aim was to design a waterborne wastewater system that would be an alternative to the conventional treatment plants. The residents wanted a local wastewater treatment system without chemical precipitation, and this was why they chose a system with urine separation, a local treatment plant and subsequent treatment in ponds and ditches. This alternative was adopted despite the option of connecting up to the nearby municipal wastewater system.

The current situation in Understenshöjden

Since the residents moved in, all the urine has been used as fertilizer for cereal crops. However, the Environment and Health Protection Administration did not grant permission to release the wastewater treated in the local plant into the system of ponds and ditches. Therefore, the water is pumped into the municipal wastewater system. The reason for this is that the treated water did not meet the limit value for phosphorus (0.5 mg per litre). It did, however, meet both the hygienic requirements and the BOD requirement of 15 mg per litre. The residents began discussions about the future of the local treatment plant.

In the most recent developments the residents decided to keep the urine-separating toilets, which they are satisfied with but have closed the local treatment plant. Currently, a new farmer is being contracted to take care of the urine produced in the area.

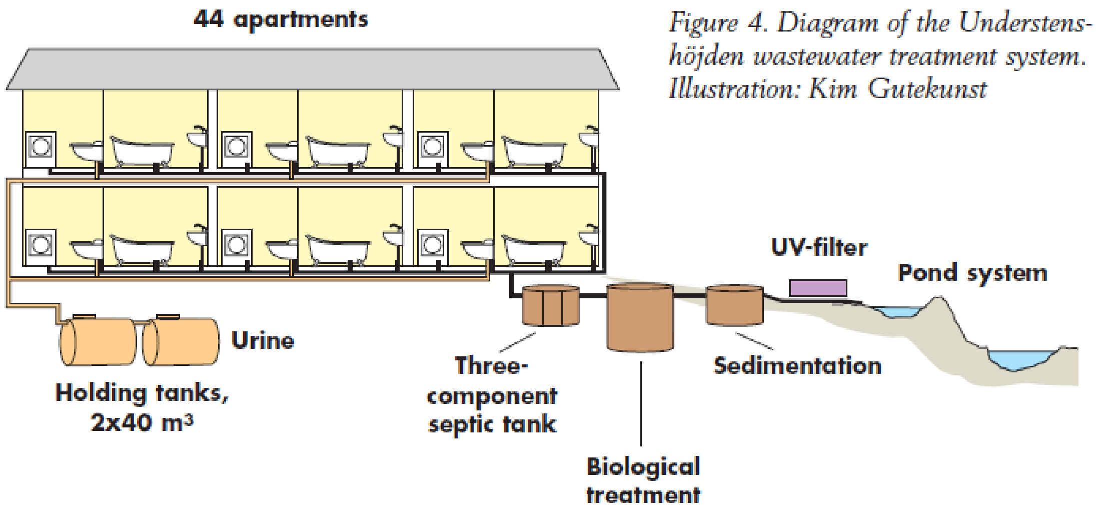

Figure 4. Diagram of the Understens-höjden wastewater treatment system. Illustration: Kim Gutekunst

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CASE STUDY 4 - Gebers collective housing project, Orhem, Sweden.

Ecological cooperative housing project using urine diverting dry toilets.

Type of Project:	Ecological cooperative housing project
Project Period:	project begun 1998
Project Scale:	32 apartments, 80 inhabitants, 3500 m² living area
Address:	Gebersvägen 20-30, S-12865 Orhem, Sweden
Planning Institution:	HSB (The National Association of Tenants Savings and Building Societies) and EKBO (Ecological Collective Housing in Orhem)
Executing Institution:	HSB and EKBO

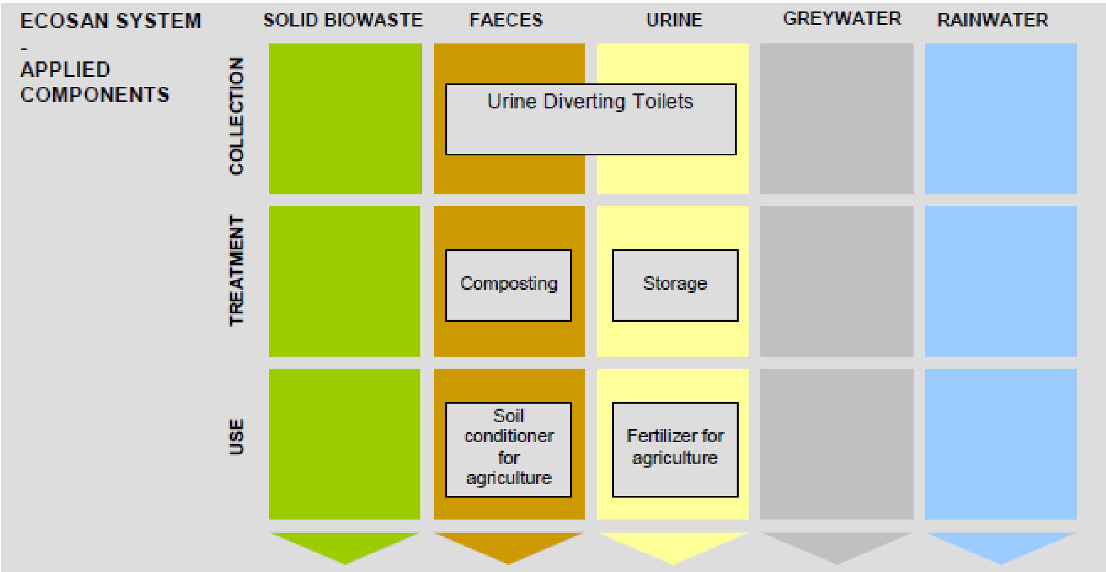

Figure 5: the ECOSAN system applied components

Objective of the project

Along with having a series of social aims, the main objectives of this project were environmental protection and the installation of systems which close the loop to the greatest possible extent. This resulted in the implementation of a holistic sanitation system that recycle all nutrients from human waste for the benefit of agriculture.

Figure 6: Gebers Building (source: VERNA Ecology Inc.)

Location and general conditions

The "Gebers" collective housing project is located in an area with a Nordic climate on a 3,2 ha site on the lake of Drevviken, in Orhem, a southern suburb of Stockholm, near a nature reserve.

The project was promoted by a network of friends and neighbours, who had a vision of communal living based upon practical, human and ecological considerations. They formed an organisation called "EKBO" (Ecological Collective Housing in Orhem) in 1995. In 1998 work began to convert the "Gebers" site, a former convalescent home which had become a deserted and vandalised building complex of 3500 m², to 32 apartments and facilities for collective use, including a large kitchen, a dining-hall, a sauna and a laundry room. Currently around 80 people live at the Gebers.

Technologies Applied

Right from the start EKBO decided to install toilets that separate urine, with the single-flush urine-diverting toilets, the “ES-Classic” model of Wost Man Ecology AB being installed.

With this model the urine bowl is flushed with 0.1 litres of water. It is piped in polypropylene pipes of 50 mm diameter to groups of polypropylene collection tanks of 10-15 m³ under the house.

The faeces are collected without flushing water and fall straight down through gravity pipes of 200 mm diameter into individual ordinary plastic bins of 140 litres in the cellar, which are removed when full.

No additional solid waste is allowed to be thrown into the toilet. An extraction system draws air from the ventilation outlet of the bathrooms through the faeces collection area and to a vent pipe on the roof of the house. This keeps the faeces bins under negative pressure, improves their dehydration and removes odours even when the toilets are in use. At present greywater is not treated locally. It is instead led to conventional gravity sewers and the Henriksdals wastewater treatment plant.

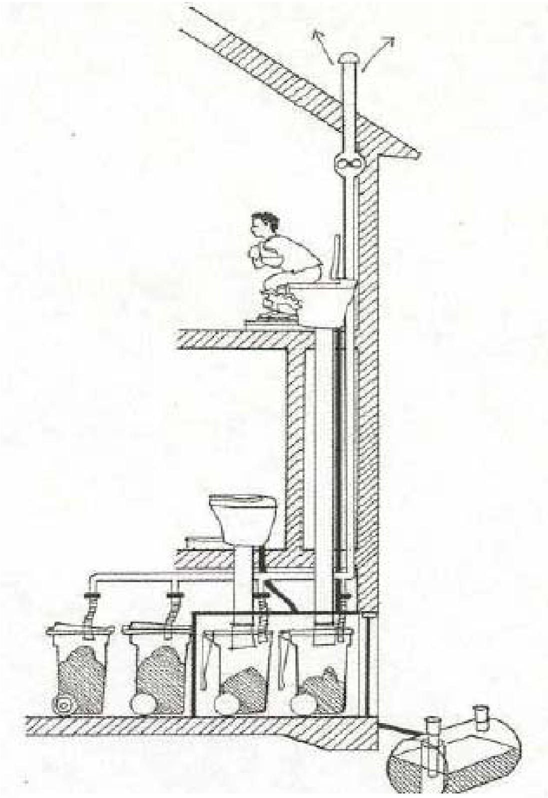

Figure 7: Gebers system sketch (source: SEI)

Figure 8: Urine Collection Tank (source: VERNA Ecol.)

Figure 9: Faeces Collection Bin (source: VERNA Ecol.)

Type of reuse
The urine tanks below the house are emptied 2-3 times a year. It is then transported to a farm 30 km south of Stockholm, where it is stored in 3 reservoirs of 150 m³ for 6 months for hygienic reasons. The treated urine is then used as fertiliser in agriculture and is enough for approximately 2 hectares (ha) of barley.



Figure 10: Urine application on the barley field (source: VERNA Ecol.)

When full, the faeces bins are transported to a composting site, approximately 200 meters from the building. Here it is composted and need only be removed after 5-6 years. It is planned to use the compost in agriculture as soil conditioner for racing horse feed on a farm 10 km away.


Figure 11: Faeces compost (source: VERNA Ecol.)

Further project components

- As stated, the adaptation to natural processes and recycling were and still are major objectives of the project. The use, and reuse, of all material related to the site and a strict use of ecological building materials were maxims for the work. A cooperative for joint buying and selling of the apartments was founded.
- It is planned to minimise the consumption of public drinking water by increasing the use of lake and rain water as well as to provide a constructed wetland for grey water treatment.

- The existing central oil heating was replaced by a pellet furnace with an accumulator tank for peak heating requirements.
- Solar panels are used to heat water.
- All electrical equipment is PVC free and as energetically economical as possible.
- The composting of faeces is combined with organic household waste.

Project History

After forming EKBO and buying the property a co-operation contract with HSB, Sweden's biggest association for cooperative housing, was concluded. They were jointly responsible for the management of the project and ran it together; with HSB providing financing and construction know-how, and EKBO providing the initiative, the organisation of the residents and the generation of ideas and practical solutions.

Such a participatory and ambitious project requires individual and innovative solutions at nearly every level. It therefore resulted in intensive discussions between the authorities, the companies involved, the future inhabitants and a range of consulting services which required a large input of both time and money.

The vague building regulations for such a conversion in particular led to some very elaborate solutions being requested by the authorities for caution reasons. Also the building itself turned out to be defective in various respects (with asbestos, damp, rot, mould).

Costs

The extra investment cost for the sanitation system was calculated to be around 90,000 USD - less than 3000 USD per apartment. This included the price for the Wost Man Ecology "ES-Classic" toilet of around 300 USD. The price for the urine collection system was approximately 500 USD per flat. The price for the faeces collection system became very high due to strict fire safety regulations, which led to additional consulting costs. This required approximately 3000 USD per apartment. Running costs for the evacuation of the urine collection tank costs approximately 1,000 USD per year.

Operation and Maintenance

Each apartment owner is responsible for the control and emptying of their faeces collection bin. They are normally emptied twice a year and deposited collectively at the composting site. The composting process is overseen by two dedicated residents of the Gebers. When completely composted it has a soil-like appearance. The urine tanks are emptied at three collection points by a tanker truck with a vacuum system and delivered to the farm.

For the time being the use of these fertilisers is a service provided by the farmers to the project, as the use of excrements is not yet officially recognised in Sweden and artificial fertiliser is relatively cheap.

Practical experience and lessons learned, comments

- Generally the project highlights how motivated and flexible stakeholders are able to find appropriate solutions for a more sustainable lifestyle.
- The overall system performance is satisfactory for the users. Some problems have occurred but were solved by improved planning and management.
- Most problems were related to urine sediments which are surprisingly voluminous. Pipes tend to get clogged if the diameter is rather small (under 50 mm) and if there are any water traps (which initially existed in the form of a narrow horizontal wastewater hose between toilet and downpipe). Cloggings can

be cleaned mechanically and with low amounts of hot water under pressure. This should be best performed when the tanks are emptied to avoid dilution of the urine.
- Any Water-traps should be avoided and are in any case unnecessary because of the ventilation system.
- Based on practical experience, a urine pipe diameter of 110 mm is recommended for the common part of the system to which all toilets are collected.
- Fly barriers, installed in places that allow an easy cleaning, should be integrated into the ventilation system.
- The addition of ash, or a more frequent (less than 6 months) emptying of the faeces bins, have both proved suitable to prevent fly invasions.
- Conventional plumbers need intensive instruction since they are normally not familiar with how the system works.
- Toilets with integrated collection bins could have saved investment costs compared to the existing system, which connects even the toilets on the second floor to the bins in the cellar.
- The average water consumption is apprixomately 110 litres, which is considered very low in Sweden.

Comments: At the time of publication, a new farmer is being contracted to take care of the urine produced in the area.

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CASE STUDY 5 - Kullön

Kullön – urine diversion in an attractive and modern residential area

A prerequisite for housing development at Kullön, an area of pristine nature in the municipality of Vaxholm, was that source-diversion of wastewater was to be used. 250 modern houses were built with double-flush urine diversion combined with tertiary wastewater treatment. Two different types of urine diverting pedestals have been installed. Collecting tanks for urine in each block of houses. A system for collection and use of urine on farmland has been organized.

Figure 12: Kullön village. (source: Ebba af Petersens, WRS)

Kullön is located on an island in the municipality of Vaxholm, not far from Stockholm. The residential area is comprised of 250 houses. The first inhabitants moved in during 2000. The area is very beautiful and has attracted mainly young, well-educated families with children.

Kullön is an area of Vaxholm with high environmental ambitions. The most thorough and attention-drawing environmental venture is the water and sanitation system. One interesting aspect of Kullön's sanitation system is the combination of urine diversion and tertiary treatment for the remaining wastewater fractions.

Technical System Design

Toilets	Gustavsberg or Dubbletten
Pipes	Plastic pipes drawn in the same pipeline trench as the other pipes. Urine has to be pumped from some parts of the area.
Tanks	Urine is collected at neighbourhood level. It is possible to transport urine straight or via overflow to the local wastewater treatment plant if needed.
Emptying/use	The tanks will be emptied by tanker trucks, through a contractor. First agricultural use of collected urine will take place during spring 2006.
Storage – sanitization	Urine storage will be arranged at the farm where the urine will be used.
Other wastewater fractions	Remaining wastewater (faeces, flush water and greywater) is treated tertially in a local wastewater treatment plant

Organization

Kullön is not only interesting due to its size, it is also interesting from an institutional point of view. In contrast to Tanum the municipality of Vaxholm initially did not want to get involved in the system for transport, storage and use of urine from the households. Their point of view was that the households themselves should solve this and contract a farmer or contractor. This led to a situation where the urine was not collected at all between 2001 and 2005, but overflowed into the wastewater treatment plant. The municipality has thereafter been forced to engage itself in stages in the organization of a urine use system.

Roles and responsibilities

The municipal water and wastewater company were responsible for contracting a farmer during 2006.

Economy

For the Swedish context it is estimated that the monetary value of the nutrients in urine corresponds to the extra costs of spreading urine compared to spreading commercial fertilizer. For large-scale systems there are also costs for storage and transport of the urine. In the Kullön case these additional costs were initially charged to the households. This means that the households at Kullön had to pay more for their water and wastewater services even though they contribute less to environmental degradation compared to other inhabitants in the municipality.

Information activities and monitoring

During 2004/2005 all new inhabitants of Kullön were trained on environmental aspects of the full technical system. Special attention was paid to the sanitation system. A detailed manual for the operation and maintenance of the urine system was produced and distributed to the households.

Lessons learned: Kullön

The Kullön case shows that urine diversion is well-suited for modern, attractive residential areas and compatible with tertiary treatment of the other wastewater fractions. This case also underlines the absolute necessity, for a residential area of this size, of clear division of responsibilities between actors in order to achieve agricultural use of the collected urine.

"We were really excited to move into a residential area where so much effort had been made to use functioning environmental technology, both regarding sanitation, solid waste and energy. We also saw that the discharge of nutrients etc would be lower from our sanitation system compared to a conventional sanitation system. The sanitation system works well for us, but the responsibility question regarding cost sharing between the municipality and the household should have been clearer from the beginning."
Rolf Svedberg, Environmental Adviser at the Environmental Court of Appeal and resident at Kullön.

"We, as developers, had expected this project to be easier than it turned out to be. The largest challenges have been organizational aspects and lack of political will at national level. A lot of responsibilities and costs have been charged to the households. Technical challenges have been easier to solve".

Ulf Jonsson, Project Manager for the developer SMÅA Hus.

Figure 13: Kullön is situated in the sensitive environment near the Baltic sea.
Photo: Anna Richert Stintzing.

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CASE STUDY 6 - Hakunge

Hakunge is closing the loop - Storage and application of urine on farmland.
Urine from the housing area at Kullön is transported to Hakunge, a farm located about 25 km from Kullön. A former collection container for manure, now equipped with a floating cover, is used for storage of urine. The cover consists of hexagon-shaped floating plastic pieces - HexaCover. The cover prevents the emissions of gases and odours such as ammonia. The surface-area of the storage is about 340 m^2. The urine is being applied on arable land after a storage period of at least 6 months.

Figure 14: floating cover of storage facility (source: Ebba af Petersens)

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BLACKWATER SYSTEMS

Blackwater is the wastewater derived from toilet wastewater. It contains about 90% of the nitrogen in combined wastewater and about 80% of the phosphorus. The separation and treatment of blackwater can yield a nutrient rich fertilizer for agricultural applications.

CASE STUDY 7 - Trosa

Trosa – Eco municipality Green spot on the CCB Hot Spot map

Trosa is a small municipality south of Stockholm, with about 11 000 inhabitants. Trosa is an Eco municipality, which means that they are focusing extra on environmental issues in their planning and decisionmaking. Trosa has also been pointed out as Green spot on the CCB Hot Spot map.

Since 1995 Trosa municipality have a system where black water from closed tanks and sludge from septic tanks and small sewage water treatment plants, is collected by a truck and transported to a storage. The storage consists of rubber or concrete tanks, which are owned by an entrepreneur, and located in connection to agricultural land. After storing for at least six months, the product is spread on the nearby fields (see figure 15). The land owner is paid a fee for taking the sludge, but the spreading is carried out by the entrepreneur.

Figure 15: Application of blackwater at Tureholm, Trosa. (source: Ebba af Petersens)

Trosa is willing to go on with the use of black water systems if the interest from the agriculture is based on long termed strategy for recycling nutrient from this kind of waste water fraction. An important aspect for the municipality is that it does not control the systems that process the black water. If the interest for using collected black water in the agriculture decreases, problems might occur that will change the point of view concerning black water systems. The efficient and ecological system might in that moment change to a non-ecological system where the collected black water becomes a problem instead of being the resource it should be. To encourage use of black water system Trosa municipality prefer a firm and long term strategy for all participating parts in the system i.e. the farmer, the entrepreneurs, the government, the authorities, the municipality.

References

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- Trosa municipality website: www.trosa.se
- Karl-Axel Reimer, municipal ecologist (Kommunekolog) email contact: karl-axel.reimer@trosa.se

CASE STUDY 8 - Trostorp

This is no ordinary toilet! - blackwater system with vacuum toilets
The toilet and wastewater system at Trostorp have been built from an idea given by WRS Uppsala with financial support from Trosa municipality. The system has been designed to be user friendly and easily maintained, at the same time as high demands on disease control, environment protection and recycling of nutrients are fulfilled. The facility is built to be able to work as a demonstration plot.

The toilet system
All three toilets at the local folklore centre Trostorp, in Trosa municipality, are extremely low-flush vacuum toilets. Vacuum toilets "flush" with air instead of water, which consumes only 0,5 - 1 litres per flush instead of 5-6 litres as in conventional toilets. A waterless urinal is also installed, which do not flush with any water at all. As Trostorp has about 3,000 visitors each year, about 16 tonnes of water is saved compared to if conventional water toilets had been used. Apart from saving water, the purpose with installing extremely low flush toilets is also to collect the nutrients in the toilet waste as concentrated as possible to be able to use it as fertilizer on farmland. The toilet water from Trostorp is collected in a tank, which is emptied one to two times a year with a tank truck. The tank truck transports the toilet water to storage tanks at farms in the municipality, where the toiletwater is stored together with sludge from septic tanks and small local package treatment plants, and toilet water from single family households. After storage/sanitization the toilet water is applied to farm land and is then replacing chemical fertilizer.

Local treatment of greywater
The greywater (wastewater from kitchen and handwashing) from Trostorp contains very little nutrients and almost no pathogens, but it contains organic material that can start to smell if it is not treated. The greywater is therefore treated in a septic tank followed by a treatment facility in the ground, a so called compact filter. In a compact filter a biofilm of bacteria and fungi is formed that decomposes the organic material in the ground. A compact filter is based on passive treatment with no movable parts. That makes it a reliable treatment facility.

Source separation of the wastewater
It is a big difference between the wastewater from the toilet (blackwater) and the wastewater from washing and dish (greywater), and by separating the two types, the wastewater is easier to clean. It is also easier to take care of the nutrients in the toilet waste in a safe way.

The main part of the wastewater is greywater which contains very little pollutants and is therefore relatively easy to treat locally. The toilet waste is a very small part of the total amount of wastewater, but contains almost all nutrients.

If the toilet waste is collected separately, emissions of nutrients to lakes and rivers is avoided, which contributes to less eutrophication. Instead the collected toilet waste can be treated and replace chemical fertilizer on farmland. Phosphorous in chemical fertilizer comes from mines and is a finite resource, and chemical fertiliser is also very energy consuming to fabricate. To have a long-term sustainable wastewater management, we therefore need to take care of the nutrients in the toilet waste.

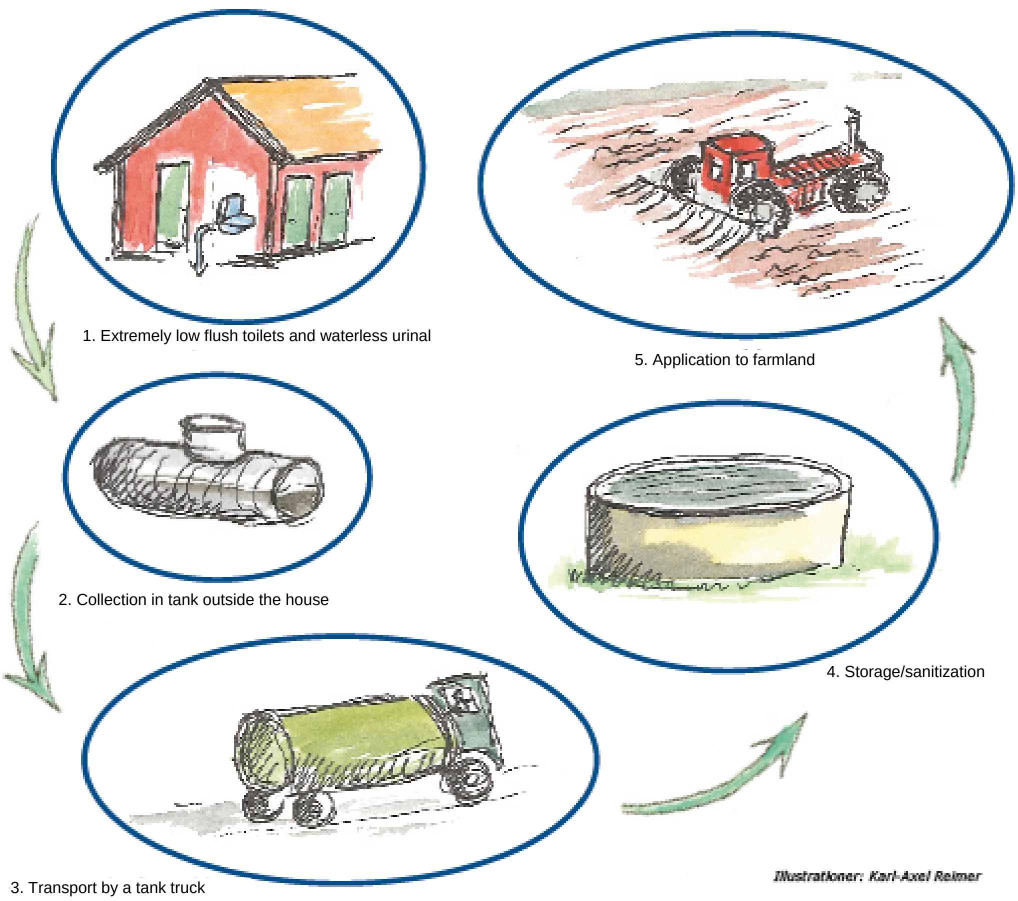


Figure 16: System flow process of collection, storage and application

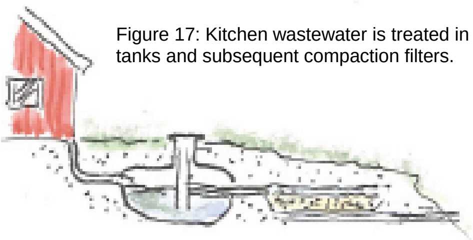
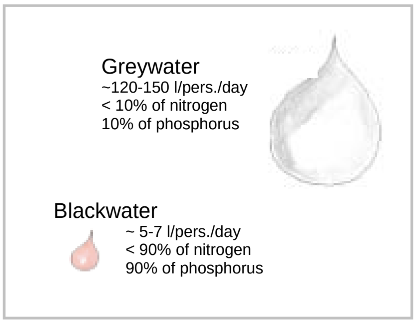


Figure 17: Kitchen wastewater is treated in septic tanks and subsequent compaction filters.



References

- Extracts from Trostorp poster courtesy of WRS - Water Revival Systems AB, Uppsala, Sweden

Additional Information

- Trosa municipality website: www.trosa.se
- Karl-Axel Reimer, municipal ecologist (Kommunekolog) email contact: karl-axel.reimer@trosa.se

CASE STUDY 9 - Tureholm

Storage and application of blackwater to farmland

At Tureholm recycling of nutrients in wet sludge/slurry from septic tanks, closed tanks and small package plants is carried out. Collection of sludge is done from septic tanks and closed tanks by a tank truck with a capacity of 8-12 m^3. The sludge is then transported to Tureholm where it is stored in an open concrete tank with a volume of 2,200 m^3. Maximum 2 transports a day is done to the storage tanks. The sludge is led from the tank truck to the open tank through a hose with tight connections, via a screening. The volume in the storage tank is replaced 1-2 times a year by application on plots nearby the tanks.

Figure 18: Emptying a tank truck into storage tank. (source: Anna Smolka, CCB Water Policy Officer)

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CASE STUDY 10 - Nynäs Castle

Biogas plant for kitchen waste

The biogas plant at Nynäs was opened in spring 2005. Here, kitchen waste from Trosa and Nyköping is transformed together with manure and silage from the farm both to plant nutrients for the crops and methane gas for electricity generator and vehicle gas. The production is about 10 m^3 of gas per day, which corresponds to 5 litres of diesel.

The plant at Nynäs is constructed for fermenting kitchen waste, manure and ley silage in order to produce plant nutrients for the farm and increase the degree of self support of energy. The plant has a permission according to the Environmental Act. Manure and ley silage is produced at the farm. Kitchen waste is delivered by Nyköping and Trosa municipalities according to a contract. The amounts delivered are at the moment not sufficient for full utilization of the plant capacity, why work is done to increase the amounts.

Figure 19: Biogas plant, Nynäs. (source: P. Carlweitz 2006)

Handling of incoming material

Kitchen waste is transported to Nynäs by garbage trucks that dump the material on a concrete surface. The material needs to be covered by a roof. The material is moved with a truck to a mixing machine, where it is turned into a porridge looking material. After that the “porridge” is emptied into a mixing container where water is added and it is shredded and mixed. The material is then pumped to a small tank (ca 1,5m^3) where hygienisation is done according to standard (70ºC for 60 minutes). Manure and ley silage is mixed with biogas residues and pumped into the digestion chamber.

The digestion process

From the hygiensation tank the material is pumped to the digestion chamber which has a volume of ca 350 m3 in total. The chamber is about 5/6 filled with substrate and digestion is done mesophilic at about 37ºC. This is a continuous process and the retention time is about 3-4 weeks. There is a complete mixing of the material in the chamber with a big propeller. The dry matter content of the incoming material is 10-12%. After digestion the dry matter content has halved.

Digestion residues

The digestion residues, an organic fertilizer rich in plant nutrients, is primarily stored in a concrete container with a tarp roof, where after it is spread on farmland or transported to another storage container. Application to farmland is done with a tank wagon trailing hoses, in order to reduce nitrogen loss. Work is done at the moment to optimize the amounts of digestion residues by correlating to the nutrient demand of the soil.

Figure 20: Digestion chamber. (source: Bosse Karp, 2006.)

Raw gas
In the digestion process raw gas (biogas) is produced. The gas is collected in the top of the chamber. The raw gas contains 60-65% methane, the rest is carbon dioxide. An overpressure (up to ca 8 mBar) is formed in the chamber during the process. The raw gas is going to a gasometer. The gas is used for production of electricity or cleaned into vehicle fuel.

Production of electricity
When producing electricity, the raw gas is going to a diesel engine that runs a generator. The generator can produce maximum 50 kW. The generator is connected to an internal electricity net on the farm. This net is communicating with the ordinary net, and electricity can be imported when shortage and exported at excess.

Vehicle fuel
When producing vehicle fuel, the gas is led to a cleaning facility. The cleaning is done with water under pressure. The gas is stored in a high pressure storage of 2 m^3 at up to 200 Bar pressure. It then contains about 90-94% methane, the rest is CO2.

References

- Translation from *http://www.nynasslott.se/admin/functions/navi/biogasanlaggningen___152.aspx*

Additional Information

- Website: www.nynasslott.se

IRRIGATION USING WASTEWATER

Irrigation using wastewater is a low-tech method for recirculation of nutrients. The method is often used on energy forest production. If there are storage dams, water can be stored during the winter and irrigated during the growing season. Two examples are given.

CASE STUDY 11 - Kågeröd

Willow (salix) irrigation

Most projects that use wastewater as a resource make a virtue of a necessity. The wastewater must be treated somehow, other options have undesireable environmental or financial consequences, and therefore ecological engineering is chosen. The Kågeröd wastewater treatment plant in Skåne, the southern part of Sweden (56° N latitude), is an exception. The facility's tertiary treatment already meets discharge parameters of 10 mg BOD_7/l and 0.3 mg P_{tot}/l. The decision was nonethless made to divert part of the wastewater from tertiary treatment with chemical precipitation to irrigate a nearby energy forest plantation, because of the water's growth-stimulating value. The municipality also wants to see how much of the treatment plant's function can be replaced by the wastewater irrigation.

Figure 21: The willow (Salix) cuttings in the energy forest take only a few years to reach harvest maturity. They are cut and made into chips for burning as fuel. The trees do not need to be replanted, as new shoots will grow from the old root system.

The Kågeröd Waste Water Treatment Plant receives wastewater from 1,500 persons and a powdered milk factory, a total of 6000-7000 person equivalent. The treatment plant has primary mechanical treatment, secondary treatment with activated sludge, and chemical precipitation of phosphorus as tertiary treatment. In 1992, an experimental irrigation of energy forests adjacent to the treatment plant was started. Effluent from the activated sludge treatment irrigates the willow plantation instead of going to the chemical precipitation step. It is applied to the willow plots at six different rates, 2, 4, 6, 8, 10 and 12 mm/day. Water is applied from May to October using sprinklers. One plot is an unirrigated control. Each plot is 30 x 30 m (900 m^2). The test area comprises, then, less than a hectare of an energy forest plantation of 14 ha. Three different cultivators of willow were tested.

Cuttings were planted in spring 1992, for a plant density of 18,000 individuals per ha. The soil is a silty clay with a 30 cm topsoil layer of silt. The field was previously used for traditional crop production and fertilized with chemical fertilizers. The project has monitored the groundwater in each plot and analyzed the wastewater, soil, groundwater, and some tree material for nutrients (N,P,K), organic material (BOD), and some heavy metals (Cu, Zn, Cd, and Pb).

The project was designed as a research project, to answer questions about how much water the willow needs for improved growth and how much irrigation with wastewater it tolerates, the economics of energy forest irrigation compared with conventional treatment, and the environmental effects. The study was evaluated and later launched to full-scale in 1997 after results showed that both the number of shoots and their height increased compared to the non-irrigated control in response to wastewater application. Irrigation with more than 6mm/day resulted in no further increase or an actual decrease in the height and number of shoots. The stem biomass was 300-400% higher with application of up to 6 mm/day wastewater than in the control, without irrigation.

Operational data over a seven year period from 1997-2004 shows clear improvements of outlet qualities of treated wastewater to the receiving river before and after the irrigation season of May – October (figure 22).

Parameter	Discharge before 1997	Discharge after 1997	Improvement rate, %
Total N, mg/l	8.2	1.7	79
NH_4-N, mg/l	2.6	0.21	92
NO_3-N, mg/l	5.0	1.2	76
Total P, mg/l	0.053	0.047	11
BOD_7, mg/l	2.9	1.3	55

Figure 22: Comparison of outlet qualities of treated wastewater for various parameters before and after full-scale project implementation (Source: Lindoff 2004)

The experiences of the system show that irrigation with biologically treated wastewater as an advanced treatment method result in lower pollution load on the river than conventional tertiary treatment. No smell and no contamination of the groundwater have been observed, and the system has worked well all summers since the start. The willow has been harvested every 4-5 years, but the harvesting costs are almost as large as the income from selling the energy forest.

This year (2009) is the first year since the start that the system is not in use. The irrigation pipes have been clogged by roots and sludge, and need restoration. The cost for repairing and replacing the pipes is estimated to about €100 000, and the municipality has not yet decided if they will invest in restoring the system. At the moment they are using chemical precipitation in the wastewater treatment plant all year around for phosphorous removal.

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CASE STUDY 12 - Enköping

Energy forest production and wastewater treatment

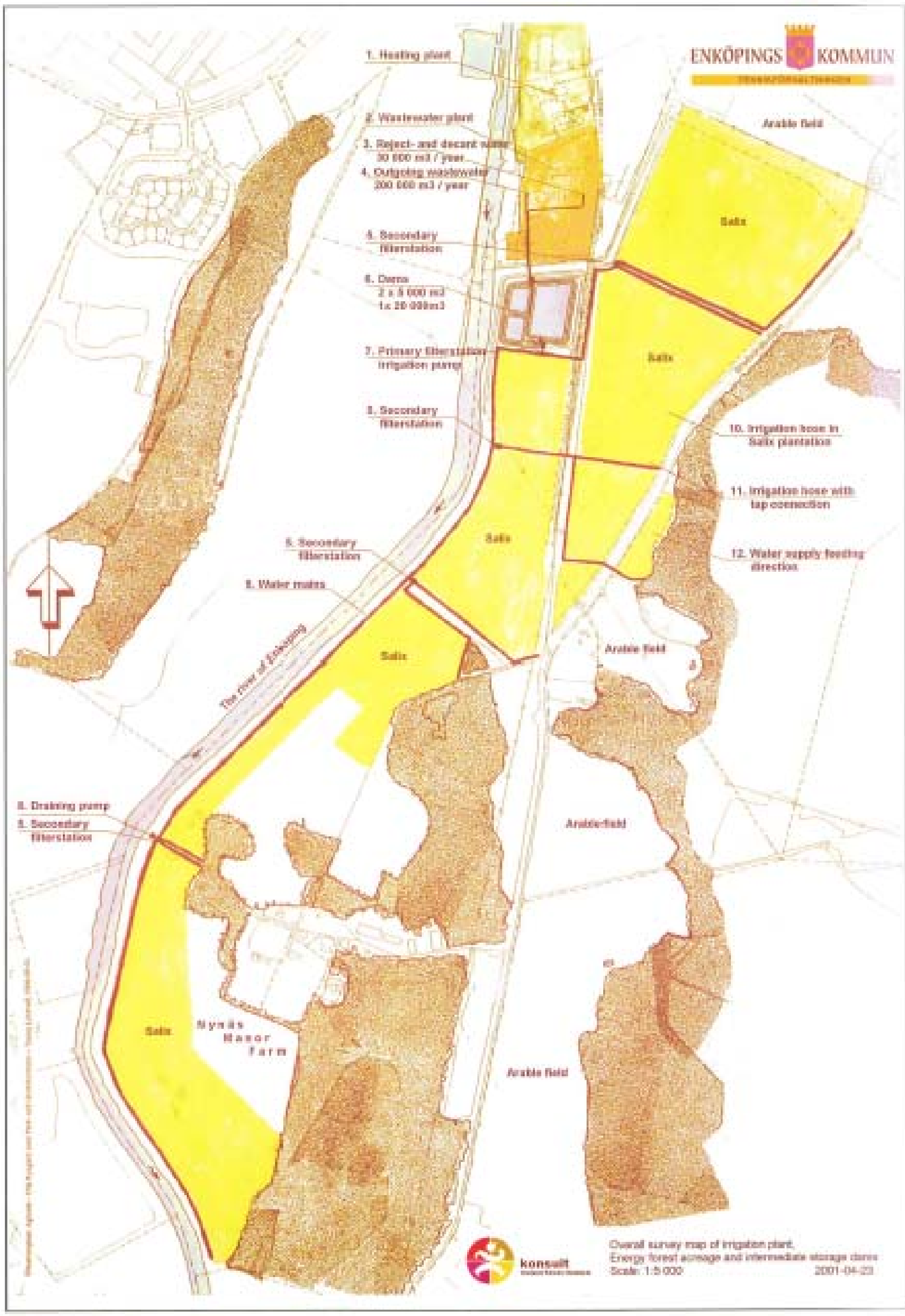
Enköping has created a system for local recirculation of nutrients from wastewater treatment plant and small scale onsite wastewater treatment facilities to energy forest production. Through a good cooperation with the local farmers, a system has been created where several wastewater fractions are recirculated back to cultivated land. This gives environmental values and benefits for the departments at the municipality, the energy company, and the local farmers. Enköping has inspired visitors from many parts of the world to think new around wastewater management, farming and energy production.

Figure 23: Storage dam for blackwater, Enköping. (source: Cecila Toresäter, Enköping municipality)

Throughout the summer period, the 80 ha energy forest at Nynäs Manor Farm is being irrigated with fertile nitrogenous water from the municipal sewage plant. The energy forest utilising the nutrients in the sludgewater for its growth. Inall, the plant manages 30 tonnes of nitrogen and 1 tonne of phosphorus per year. After about two or three years the energy forest is harvested and the chips is burnt on the municipal biofuelled heating plant, ENA Kraft, generating heat and electricity.

The salix plantations at Nynäs Manor Farm have an annual average yield of 5 GWh, which is the equivalent of two percent of ENA Kraft's total requirements of biofuel.

The energy forest plantations at Nynäs Manor Farm are divided into six different units, each unit watered for a full three hours every day. The units vary in size from 10 to 15 ha. Salix needs a generous supply of water during its period of growth which means that the energy plantation is irrigated 90 days a year. A total amount of 200,000 m^3 of water (of which 30,000 m^3 is reject and decant water) will be dispersed each year. This is the equivalent of a 3 mm rainfall every 24 hours.



References

- Extract from: Welcome to Enköping – the largest combined energy forest and nutrient filtrations facility (pdf) courtesy of WRS, Uppsala.

Additional Information

- Enköping municipality website: www.enkoping.se
- Ulf Pilö, municipal officer email contact ulf.pilo@enkoping.se
- ENA Energi AB website: www.enae.se